

E81-1 0215

CR-144745

Michigan State University

East Lansing, Michigan 48824

M 78-20570

USE OF REMOTE SENSING FOR LAND USE
POLICY FORMULATION

Semi-Annual Progress Report, June 1977 - November 1977

Prepared For

Office of University Affairs
National Aeronautics and Space Administration
Washington, D.C.

NASA Grant Number: NGL 23-004-083

"Made available under NASA sponsorship
in the interest of early and wide dis-
semination of Earth Resources Survey
Program information and without liability
for any use made thereof."

Myles Boylan

Myles Boylan, Principal Investigator
Professor, School of Urban Planning
and Landscape Architecture

Raymond D. Vlasin
Raymond D. Vlasin, Chairman and
Professor, Department of Resource
Development

March 14, 1978

Table of Contents

USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

	<u>Page</u>
Scope of Report	1
ACKNOWLEDGEMENTS.	2
INTRODUCTION.	3
A. DEMONSTRATION APPLICATIONS.	9
1. Mosquito Control in Saginaw and Bay Counties	10
2. Identification of Wild Areas in Southern Lower Michigan.	13
3. Muskegon Sand Mining Inventory	21
4. Preservation of the Grand Mere Dune Environment.	30
B. USER SERVICES	32
1. Institutionalization of the Remote Sensing Project	34
2. Working Association with the Cooperative Extension Service	37
C. CONTRACTUAL SERVICES.	39
1. Comprehensive Resource Inventory and Evaluation System (CRIES).	40
2. Inventory of Sand Mining Sites in Michigan's High-Priority Sand Dune Areas.	42
3. Inventory of Sand Dune Types in Michigan's High-Priority Sand Dune Areas.	44
4. Shiawassee National Wildlife Refuge Vegetation Inventory	47
APPENDIX: Publications and Presentations	48

S c o p e o f R e p o r t

This document reports the remote sensing research and service activities carried out during the first half of the 1977-78 grant year from June 1, 1977 through November 30, 1977 by a team of faculty investigators and a staff of research specialists and assistants within the Remote Sensing Project of Michigan State University. It is a continuation of the Semi-Annual Progress Report, dated August 28, 1977 which covered the period December 1, 1976 through May 31, 1977.

A C K N O W L E D G E M E N T S

The investigations described in this report were made possible by the financial support of the National Aeronautics and Space Administration through the Office of University Affairs, under NASA Grant Number NGL 23-004-083. Joseph A. Vitale, Chief, Engineering Systems Design Branch, Office of University Affairs, served as the Technical Officer.

Faculty Investigators:

- + Myles Boylan (Principal Investigator), Professor, School of Urban Planning and Landscape Architecture.
- + Raymond D. Vlasin, Chairman and Professor, Department of Resource Development.
- + Dieter Brunnschweiler, Professor, Department of Geography.
- + Anil K. Jain, Assistant Professor, Department of Computer Science.
- + Delbert L. Mokma, Assistant Professor, Department of Crop and Soil Sciences.
- + Wayne L. Myers, Associate Professor, Department of Forestry.
- + Gene R. Safir, Assistant Professor, Department of Botany and Plant Pathology.
- + Ronald L. Shelton, Associate Professor, Department of Resource Development and School of Urban Planning and Landscape Architecture.
- + Eugene P. Whiteside, Professor, Department of Crop and Soil Sciences.

Project Research Staff:

- + William R. Enslin, Research Specialist--Project Director
- + Christopher Cialek, Research Specialist
- + Sandra M. Habowski, Research Specialist
- + Stephen E. Tilmann, Research Specialist
- + John A. Harrington, Jr., Graduate Research Assistant
- + Richard Hill-Rowley, Graduate Research Assistant
- + Ger Schultink, Graduate Research Assistant

I N T R O D U C T I O N

The capabilities of remote sensing are being acknowledged increasingly as a major technological means for providing crucial information for a substantial range of societal programs. Prominent among these are the need for protecting the integrity of natural and human environments. Overall, the quality of land and water resources in the United States continues to deteriorate as abuses, misuses, and exploitive actions proliferate. Many dramatic remedial programs have been enacted which are showing early evidences of emerging successes; but the increasing accumulation of human errors and misjudgements require unrelenting competent actions in identifying, evaluating, and eradicating base causes of environmental problems.

Public awareness of this situation has been growing rapidly over the past two decades. There are clear examples that the enactment of land and water resource use controls are intensifying spectacularly, and "on-land" actions for ameliorating, and even eliminating, abusive practices are mounting in number and frequency. There are, however, on-land activities that continue to be serious problems despite recent federal, state, and local governmental enactments for modifying or eradicating negative consequences.

A brief consideration of some prominent current issues evoke multiple associations of related problems and concerns. Exploration, excavation/drilling for energy fuels; open-pit extraction of metallic ores and aggregate soils; nuclear power generation; water and air pollution; energy conservation; environmental health hazards from disease-carrying insects,

vermin, etc.; continuing urban intrusions into crucial, diminishing lands and waters; movements for rigorous growth management of urban settlements; the private auto versus mass transportation; ecological and material issues related to coastal lands, flood plains, estuarine areas, and other shore lands; inadequacies of urban structure; carrying capacities of the natural resource base. . .these kinds of real, on-land events will be generating needs for high priority research and remedial actions for a very long time.

Any effective addressing of such issues requires solid information. . . information of enlarged scope and detail; of high reliability; of recent recording and availability; and low in acquisition cost is essential for achieving competent analyses which can provide the bases for effective formulations of policies, for decisions on remedial programs, and for implementing actions.

Clearly, remotely sensed imagery as a source for a substantial range of information meets all of these criteria. The Michigan State University Project in Remote Sensing has been utilizing appropriate kinds of imagery in a continuing process to contribute essential information to agencies at all levels of government in Michigan, as well as to private organizations, for bringing about on-land actions of many kinds by which corrective and preventative measures can be carried out for preserving and conserving remaining qualities of the natural and human environments. As an extension of the many applications accomplished within previous grant periods (attention is invited to the accompanying Table 1: "Characteristics of Remote Sensing Applications in Michigan," pages 6-8), the

achievements within this reporting period demonstrate the persistence of the MSU program in broadening the community of information users. . . steadily adding to the effectiveness of state, regional, local, and some federal agencies in satisfying the increasingly insistent demands for competent territorial and resource management.

In addition to conducting demonstration applications of remote sensing, the Project faculty investigators and research staff augment these efforts with various kinds of services to users, including some instruction and training. The synopses which follow describe the individual activities carried out during the June 1 to November 30, 1977 portion of the current 1977-78 grant year.

It continues to be useful to report Project activities under the three broad groupings noted in previous period reports, namely: (a) demonstration applications; (b) user services; (c) contracted services. Not all of these are carried out with NASA grant funds, particularly contracted services in which the user pays for all related costs. User services often are paid for by the beneficiaries; but in this period the two categories of service reported involved limited costs. For example, the printing and distribution of the Guide to Aerial Imagery of Michigan was financed by the Michigan State University Agricultural Experiment Station with the Michigan State Department of Natural Resources paying for the loose-leaf binders.

Table 1

CHARACTERISTICS OF REMOTE SENSING APPLICATIONS IN MICHIGAN

Application	Agency	Area	Inventory/ Year	Imagery Used	Minimum Type/Cell size	Decision(s) or action(s) to date.
1. Highway Environmental Impact Assessment	Michigan Dept. of State Highways and Transportation	Highway M-14, Washtenaw County	12-category land use (1972)	Various types and scales	2 ha (5 acres)	Implementation of remote sensing procedures for route location in the MDSHT.
2. Waterfowl Habitat and Shoreline Assessment	Michigan Dept. of Natural Resources	Pte. Mouillee, Monroe County	19-category vegetation communities (1972-73)	1:4,000 & 1:8,000 CIR	<0.1 ha ($\frac{1}{4}$ acre)	Recommendations for more effective marsh management and alleviating shoreline erosion.
3. Multi-Agency Watershed Planning	U.S. Soil Conservation Service	Kalamazoo Watershed	22-category land use (1973-74)	1:31,680 CIR	4 ha (10 acres)	Recommendations for management of wildlife habitats & wetlands.
4. Michigan Land Cover/Use Classification Test	Office of Land Use, Michigan Dept. of Natural Resources	Ionia Co. & Macosta Co.	Multi-level Classification (1974)	Various types and scales	4 ha (10 acres)	Revision of classification system.
5. Highway Corridor Selection and County Planning	Michigan Dept. of State Highways & Traverse Bay Reg. Plng. Commission	Grand Traverse County	24-category land use & 34-category special environments (1974)	1:36,000 CIR	4 ha (10 acres)	Determined location for an industrial park.
6. Timber Management & Utilization	Mason Co. Soil Conservation District, West Mich. Reg. Plng. Comm., Packaging Corp. of America	Mason County	6 forest species groups, 3 stocking levels & 3 maturity classes (1974)	1:36,000 CIR	4 ha (10 acres)	Identification of merchantable timber and combining small private holdings into cooperative forest management units.
7. Retention of Agricultural Land	Wayne County Planning Commission	Wayne County	8-category land use (1974)	1:120,000 CIR	2 ha (5 acres)	5 townships have identified lands for retention.
8. Michigan Soil Erosion & Sedimentation Control Act (P.A. 347, 1972)	Antrim County Planning Department	Antrim County	Site conditions (1974)	1:36,000 CIR	N/A	Denial or approval of earth change site plans and issuing stop-work orders for violations.
9. Land Appraisal & Tax Equalization	Charlevoix County Equalization Department	Islands of Charlevoix County	6-category land cover (1975)	1:120,000 CIR	2 ha (5 acres)	Re-appraised property value and tax assessment.
10. Regional Planning	Southeast Michigan Council of Governments	7 county area in S.E. Mich.	8-category land use (1975)	1:24,000 Pan & 1:60,000 & 1:120,000 CIR	0.4 ha (1 acre)	General land use planning decisions
11. County Wide Clean-Up of Abandoned Vehicles	Antrim County Planning Department	Antrim County	Abandoned Vehicles (1975)	1:36,000 CIR	N/A	Removal of vehicles & enactment of junk vehicle ordinance.
12. Agri-business Plant Location	Wicks Agriculture	Saginaw Bay Area	Agricultural lands (1975)	1:120,000 CIR, Skylab	4 ha (10 acres)	Selection of crop processing plant location.
13. Determining Water Areas Available for Recharging Fire Truck Supply	Antrim County Planning Department & Fire Department	Antrim County	4-waterbody and 6 accessibility parameters (1975-76)	1:36,000 CIR	0.2 ha ($\frac{1}{2}$ acre)	Anticipated increase in fire fighting efficiency.

CHARACTERISTICS OF REMOTE SENSING APPLICATIONS IN MICHIGAN
(continued)

Application	Agency	Area	Inventory/ Year	Imagery Used	Minimum Type/Cell size	Decision(s) or action(s) to date.
14. Survey of River Front Activities	Wayne County Planning Commission	Detroit Riverfront	8-category land use, marinas & stockpiles (1975)	Various types and scales	4 ha (10 acres)	Base data for long range planning of Riverfront development
15. Assessment of Recreation Potential for Back-country Rivers	North Central Forest Experiment Station	Pine River Wexford Co.	60 recreation-oriented parameters (1975)	1:36,000 CIR, 1:15,840 BWIR	1/4 mile segments	Establishment of methodology for photo acquisition of data.
16. Mosquito Abatement	Vector Control, City of Lansing	Lansing and East Lansing	Waterbodies and wetlands (1976)	1:18,000 Color	<0.1 ha (1/4 acre)	Provision of maps to direct field treatment teams
17. Acquisition and Development of Indian Treaty Lands	Saginaw-Chippewa Tribe	Isabella County	16-category land cover/use and soils information (1976)	1:40,000 Pan	4 ha (10 acres)	Information for land acquisition and development
18. Inventory for Water Quality Planning	Tri-County Regional Planning Commission (TCRPC)	Clinton, Eaton, Ingham Co.	22-category land cover/use (1976)	1:60,000 & 1:120,000 CIR	4 ha (10 acres)	Regional data for on-going planning program
19. Analysis for Water Quality Planning	TCRPC	Windsor Twp. Eaton Co.	Land cover/use, soils and geologic information (1976)	N/A	4 ha (10 acres)	Eleven thematic maps for on-going planning program
20. Biomass Estimation	Institute of Water Research, MSU	MSU Waste-water System, Ingham Co.	5-tonal density levels of an old-field ecosystem (1976)	1:6,700 CIR	N/A	CIR interpretation is effective for pre-harvest biomass estimation
21. Sand Dune Preservation	Grand Mere Association	Grand Mere area, Berrien County	Off-Road Vehicle impact on vegetation (1977)	1:14,000 Color	N/A	Impact statement to support banning off-road vehicles
22. Computer-Assisted Farmland Assessment	Eaton County Equalization Department	Eaton Co. Kent Co.	Agricultural Lands & soils data (1977)	N/A	4 ha (10 acres)	Procedure currently being implemented by user agency
23. Inventory for Water Quality Planning	Region V Planning Commission and Bendix Corp.	Genesee, Lapeer & Shiawassee Co.	12-category land cover/use. 8 categories from photo sources (MSU) 4 categories from LANDSAT (Bendix) (1977)	1:60,000 & 1:120,000 CIR LANDSAT	264 ha (5610 acres)	Regional data for on-going planning program.
24. Identification of Unique Farmlands	U.S. Soil Conservation Service	Lapeer, Macomb, Muskegon, St. Clair & Washtenaw Co.	Water, urban and unique farmlands; e.g. specialty crops (1977)	Various scales CIR & Pan	4 ha (10 acres)	Provision of data for the Land Inventory & Monitoring (LIM) Program of U.S.D.A.
25. Mosquito Control	Saginaw-Bay Mosquito Control Commission	Saginaw & Bay Co.	Potential mosquito breeding sites (1977-78)	Various types and scales	Varies	Provision of data to direct field treatment teams

CHARACTERISTICS OF REMOTE SENSING APPLICATIONS IN MICHIGAN
(continued)

Application	Agency	Area	Inventory/ Year	Imagery Used	Minimum Type/Cell size	Decision(s) or action(s) to date.
26. Identification of Wild Areas	Wilderness & Natural Areas Program, Michigan Depart- ment of Natural Resources	East Central Michigan	Potential wild areas (1977-78)	Various types and scales	Varies	Provision of data for eval- uation of potential wild areas
27. Inventory of Sand Mining Activities	Geology Division, Michigan Department of Natural Re- sources	Shoreland of Lake Michi- gan	Sand Mining Opera- tions (1977-78)	Various types and scales	Varies	Data requirement of Michigan "Sand Dune Protection and Management Act"
28. Inventory of Sand Dune Types	Geology Division, Michigan Department of Natural Re- sources	Shoreland of Lake Michi- gan	Dune types, in par- ticular barrier dunes (1977-78)	Various types and scales	Varies	Data requirement of Michigan "Sand Dune Protection and Management Act"
29. Preparation of Master Plan for Shiawassee NWR	U.S. Fish and Wildlife Service	Shiawassee NWR, Saginaw Co.	Land cover inventory (1977-78)	1:20,000 and 1:8,000 Pan	1 ha (2.5 acres)	Data element in Master Plan preparation

A. DEMONSTRATION APPLICATIONS

Research engagements described in the synopses to follow are those which were brought to the attention of the Project staff by public and quasi-public agencies which were seeking assistance for either solving problems or in meeting some statutory mandates. The Project policies require that such requests meet certain basic criteria. First, any engagement has to require reliance on data and information derived from remotely sensed imagery; second, that resultant decisions and actions would be generated predominantly from this information; third, that the research would require innovative, non-routine methods; and, fourth, that the effort offers substantial promise of resulting in early on-land actions.

Project costs for demonstration applications are met by the NASA Grant funds; but when the agency actions become operational, the user picks up full costs thereafter. In some instances, the user shares costs from the very beginning, particularly when there is close collaboration. In other instances, users gradually take over full management of a study for continuation or extension to more advanced stages as they develop their own technical skills. A large proportion of all demonstration applications completed were not solicited by the Remote Sensing Project staff; but were requested originally by user agencies. Of those reported in this document, all were unsolicited.

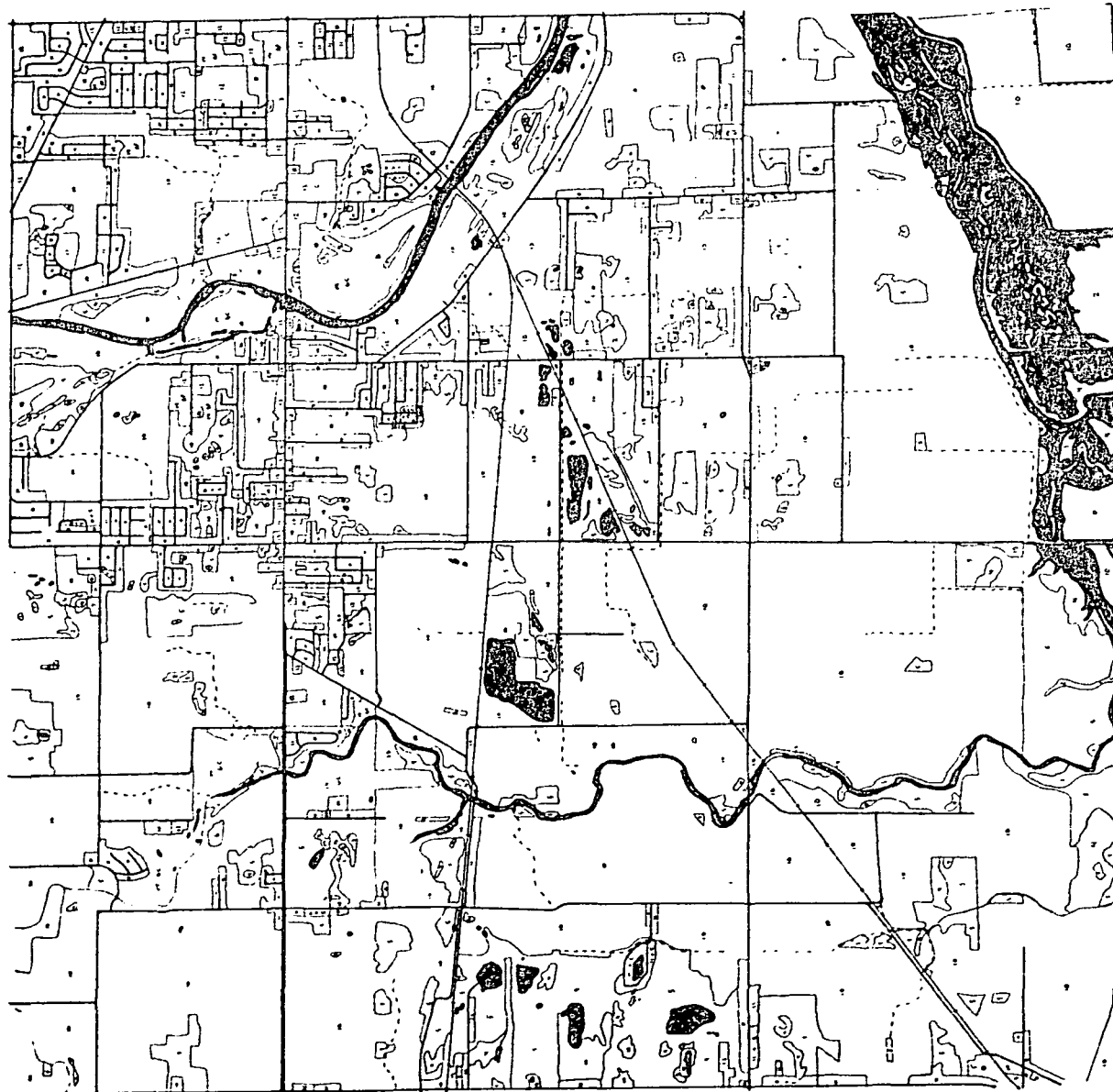
A1. Mosquito Control in Saginaw and Bay Counties

Saginaw-Bay Mosquito Control Commission (SBMCC)
1416 South River Road
Bay City, Michigan 48706

An extensive inventory of habitats considered important in mosquito control activities was provided to the SBMCC. This work was detailed in our last reporting period. The utility of this information was evaluated in July 1977. Maps of Forested Wetlands and Residential Areas were used directly in surveillance activities. The maps of Open Water and Marshes were not as useful because the minimum type size (10 acres) was too large, and the classification scheme obscured critical environmental differences. It was decided to develop a more detailed classification scheme and interpret at a finer level from NASA 1:60,000 color infrared photography. It was also decided to re-format the data on township maps to facilitate easy field use. A map (Fig. 1) has been produced of a test area which will be evaluated at the beginning of the treatment season this spring. Work is also proceeding with the development of a computer-based information and analysis system which will allow the integration of data derived from remote sensing with other sources for operational surveillance.

In October 1977 the Project worked closely with the SBMCC in the organization of a symposium on Arthropod Disease Surveillance and Control. Dr. Charles M. Barnes from NASA Houston was a featured speaker in an afternoon session devoted to "Remote Sensing as a Tool in Disease Vector Surveillance and Control." As a result of this conference the Project has been invited to organize a remote sensing session in conjunction with the

SAGINAW - BAY MOSQUITO HABITAT INVENTORY: PRELIMINARY MAP OF SWAN CREEK AREA



DMR CLASS*	MAP NUMBER	LAND COVER DESCRIPTION
611	1	WOODED SWAMP
521	2	MARSHLAND MEADOW
523	3	MARSH
414**	4	SEASONALLY WET BROADLEAVED FOREST AREAS
41	5	BROADLEAVED FOREST
42	6	CONIFEROUS FOREST
43	7	MIXED CONIFER-BROADLEAVED FOREST
1464	8	SOLID WASTE DISPOSAL
1466	9	WASTE WATER TREATMENT
2	10	AGRICULTURE OR RANGELAND
11	11	RESIDENTIAL
12	12	URBAN (COMMERCIAL, INSTITUTIONAL, INDUSTRIAL, OTHER)
192	13	OUTDOOR PUBLIC ASSEMBLY
		AP - AMUSEMENT PARK
		C - CEMETERY
		DI - DRIVE-IN
		F - FAIRGROUND
		R - RACE TRACK
		S - STADIUM
193	14	OUTDOOR RECREATION
		AF - ATHLETIC FIELD
		GC - GOLF COURSE
		P - PARK
		SR - SHOOTING RANGE
51.52		OPEN WATER
		DRAINAGE DITCHES
142		RAIL TRANSPORT (NON-ACCESS)
144		ROAD TRANSPORT (ACCESS)

* MICHIGAN LAND COVER/USE CLASSIFICATION SYSTEM, JULY 1975.
** THIS CATEGORY IS NOT LISTED SEPARATELY IN THE DMR CLASSIFICATION.

Source:

1975 NASA COLOR INFRARED AERIAL PHOTOGRAPHY.

Scale: 1 inch = 1 mile
1:62,500

Prepared by:
REMOTE SENSING PROJECT
MICHIGAN STATE UNIVERSITY
EAST LANSING, MICHIGAN 48824

Figure 1.--Preliminary Township Mosquito Habitat Map.

SBMCC at the American Mosquito Control Association meetings in Chicago in April. These activities are showing people directly involved with surveillance operations that remote sensing and associated geographic information system technology have an important role to play in their work.

A2. Identification of Wild Areas in Southern Lower Michigan

Wilderness and Natural Areas Program
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

On August 3, 1972 the Governor of the State of Michigan approved House Bill No. 4881, the "Wilderness and Natural Areas Act." This bill authorizes the state to create and regulate tracts of undeveloped state land or water for natural preservation. Responsible for identification and recommendation of these "wild areas," is the Michigan Department of Natural Resources (DNR). The purpose of setting aside wild areas is to provide wilderness-like areas in relative proximity to urban centers of more than 100,000 population that will offer outstanding opportunity for solitude and an environment for primitive and unconfined types of recreation. Once dedicated, specific activities are prohibited on these lands such as altering vegetation, creation of easements, mineral exploration and commercial enterprise.

Although the Act has been in existence over five years, no areas to date have been set aside or dedicated as wild areas. The provisions of such areas near large clusters of population, as the legislators intended, is indeed statutory. The DNR, therefore, needs an inventory of potential wild areas in the southern lower peninsula of Michigan--both those on private lands (for potential acquisition) and those on public lands (for possible dedication). The DNR has requested assistance from the Remote Sensing Project to develop an inventory methodology by which the DNR or MSU under a contractual arrangement can identify wild areas throughout the State.

Investigators for the Remote Sensing Project are currently involved in a study to develop a workable procedure for determining wild area locations near urban areas in Southern Lower Michigan. Subsequently, the procedure is being applied to selected study sites to test its feasibility and to detect and eliminate problem sources.

Study Site

The study area (Fig. 2) consists of 6 counties in Southern Lower Michigan which the investigators believe offer a diverse variety of geography. The variety of terrain, from flat lake beds in Bay County to the moraine systems of Livingston County to sand dunes of Allegan County have been chosen to provide a rigorous test of wild area criteria that could eventually be refined and applied throughout the entire Lower Peninsula.

Criteria

A list of criteria has been designed in outline form consisting of many physical properties which could be expected to be found in the Lower Peninsula of Michigan (Fig. 3). Site characteristics such as relief, soils, landforms, vegetation, hydrography are those which will need consideration in determining suitability for "wild area" designation and are included in this list.

These general criteria have been subdivided allowing investigators to check off features unique to any one sample site. The result is a check list that gives a basic description of each sample site identified, giving a general impression of the suitability for "wild area" designation.

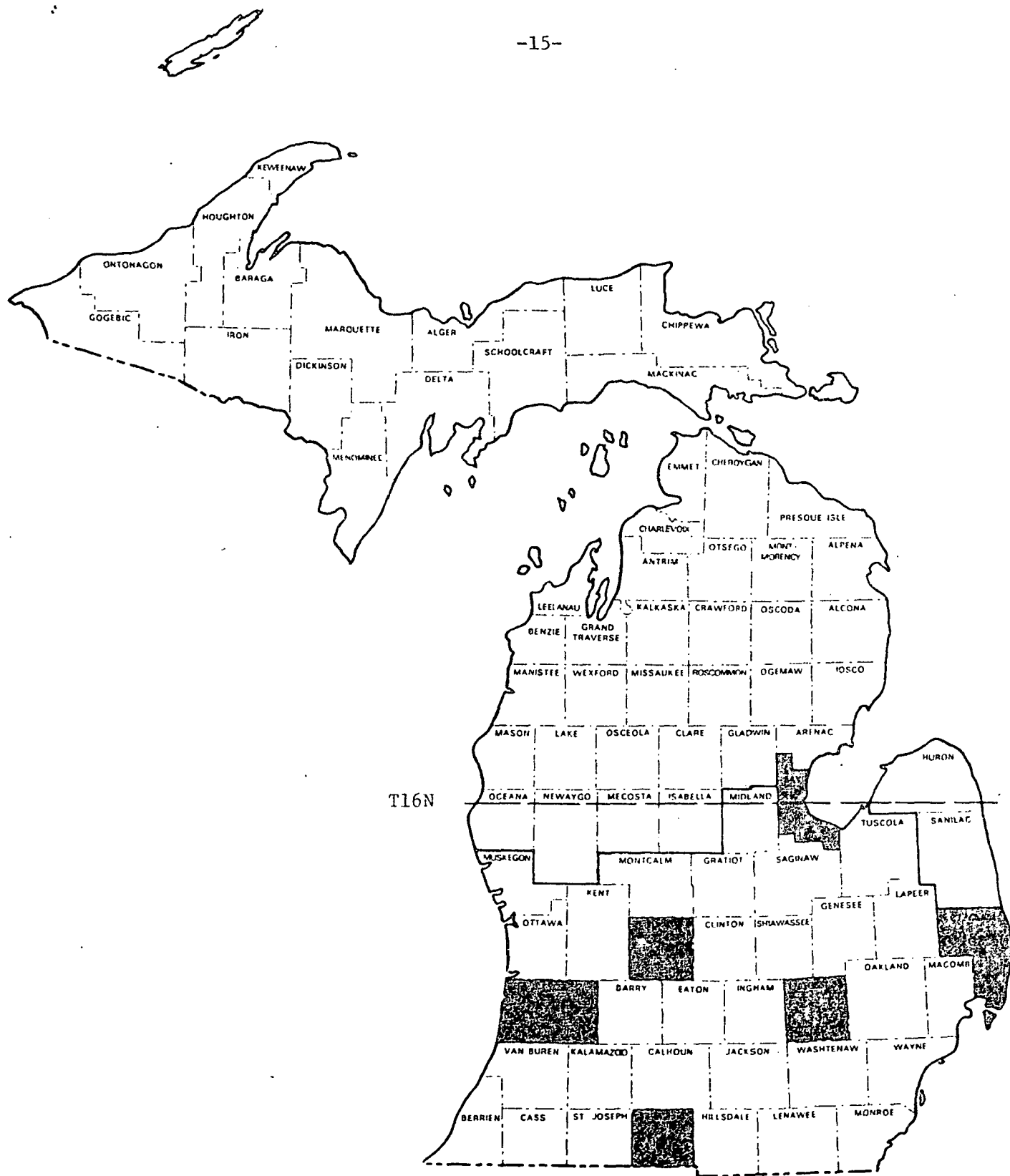


Figure 2.--Six County Wild Area Identification Study Site.

Grading Scheme

To aid in the ordering of the desirability of "wild areas," a numerical value has been assigned to each portion of the checklist. For example, if two sites are found containing different landforms, the one consisting of a river cut bluff or cliff will be given a higher numerical value (grade) over an area completely made up of a gently sloping outwash plain. All of these weight factors will be totaled for each potential "wild area" site, giving a numerical total for each area. In this way it will be possible to take the great variety of natural features in a sample area and quantify them in an attempt to determine which of these areas will be best suited to be assigned as "wild areas."

As a method of implementing this grading procedure a checklist including numerical values has been drawn up by examining three sources of land cover/use information. This list also provides a tally of available information from each of three identification sources.

Source Level One--Orbital Imagery

The initial identification of potential wild area locations is being determined from imagery taken from orbiting spacecraft.

An initial search was undertaken using an I²S Color Additive Viewer and LANDSAT imagery chips (bands 4, 5, 6, 7) of scenes which included each study county. General "natural areas" maps were traced from these scenes, outlining large tracts of land which seemed likely to contain undisturbed acreage. A more detailed search is planned using LANDSAT false color composite transparencies. It has been determined in a preliminary search with one such scene containing Ionia County, that undeveloped forested areas show

up quite well under magnification. This gives a good indication of locations suitable for further, more scrutinizing evaluation.

Frames of 70 mm. CIR SKYLAB photography, now being assembled, will also be used to interpret broad scale features. Additional detail not detected from LANDSAT will hopefully be visible on the larger scale SKYLAB photography.

Used in conjunction, orbiting spacecraft imagery will provide information in locating potential wild area sites and will give clues as to the specific site characteristics of each.

Source Level Two--High & Medium Altitude Imagery

To better substantiate this initial search, a second review of the entire test area has taken place through interpretation of high altitude color infrared photography taken from NASA aircraft at scales of 1:120,000, 1:60,000 and 1:36,000. During this step in the procedure, areas delimited using LANDSAT scenes which, upon closer inspection, did not meet "wild area" criteria (i.e., size: > 80 acres, < 3,000) were eliminated from consideration. Conversely, smaller areas, which were overlooked using orbiting spacecraft imagery have been added to the potential list. All considered areas have been delineated on acetate overlays, measured in size using an overlay grid and tabulated. At the completion of the first phase of this search, the number of potential wild areas by county are listed below.

<u>County</u>	<u># of WA Sites</u>	<u>Total Acreage</u>
Allegan	14	9,030
Bay	7	8,060
Branch	6	1,775
Ionia	5	2,960
Livingston	5	3,200
St. Clair	12	7,300

Source Level Three--Maps

As a supplement to aerial photography and space imagery interpretation, a third source of land use/cover information will be consulted. This will incorporate the use of topographic, soils, and land use maps to extract additional information which would be difficult, if not impossible to detect from photographs. Data such as local relief, soil type and texture, slope, and drainage characteristics will be recorded for each potential area. As in previous steps, a grading scheme will be applied to the results of this portion of the investigation.

Field Check

The final step in the evaluation of potential wild area sites will consist of on-site investigation. A number of potential "wild areas" will be identified using the three sources of information. Investigators will, as a final interpretation, inspect each area to determine 1) off-site quality, 2) human influences to the area, and 3) other considerations which may not have been recognized through remote sensing evaluation.

Conclusion

Ultimately the DNR will be provided with a procedural scheme which can be adapted to variation in study site size. Should a large area (state or region) be chosen for "wild area" evaluation, techniques implementing LANDSAT and SKYLAB imagery will be more time/cost efficient and provide a good analysis of potential "wild area" locations. If a closer inspection is desired (county level), techniques applied to high and medium altitude aerial imagery analysis and the use of base and thematic maps can be used providing an even more scrutinizing search for wild areas.

The limit to which each of these source levels can be applied to the search for wild area locations will become more apparent as they are more thoroughly evaluated by the use of the proposed grading scheme.

A3. Muskegon Sand Mining Inventory

Geology Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

Introduction

Recently, the bill aimed at protecting sand dunes along Michigan's Great Lakes shoreline received final legislative approval. The "Sand Dune Protection and Management Act" (Act No. 222, State of Michigan, July 30, 1976) provides for study, protection and management of shoreland dunes, prescribing power and duties to the Michigan Department of Natural Resources (DNR) for administration and enforcement, primarily in the zone within two miles of the ordinary highwater mark. A major part of the Act calls for a comprehensive study and inventory of sand mining practices and their environmental impact.

A specific management objective deals with sand mining operations affecting the future existence and use of major sand dune complexes along Michigan's shoreline.

Such a detailed assessment process aimed at qualifying and quantifying environmental indicators in areas with highly dynamic characteristics, caused by natural and man-made processes seemed to present an excellent opportunity for remote sensing involvement.

The selection of the appropriate remote sensing techniques would allow for a great flexibility in data extraction and ensure both the appropriate level of detail and timeliness of information, this being an essential

prerequisite in adequate management and law enforcement practices.

Meetings between DNR's Geology Division and the Michigan State University Remote Sensing Project (RSP) resulted in the development of two inventory procedures for a selected test area. The first one, to be carried out by the DNR, using readily available information such as USGS maps, ownership information and limited field data and the second one to be carried out by the Remote Sensing Project utilizing remote sensing sources, techniques, etc.

The Remote Sensing Project Inventory Procedure

The procedure as used in the Muskegon Sand Mining Inventory is outlined in Figure 4 (solid lines). The Muskegon test area was selected because it represents one of the highest priority areas for inventory work, and also because it is large enough to be representative, in terms of procedural developments and costs involved, for determining a state-wide sand mining inventory effort.

The basic source of remote sensing imagery selected for use in manual interpretation was NASA high altitude photography, Mission 103, scale 1:118,000, flown on September 10, 1969, from 10.00-11.15 local time. Frames #5831, 5778, and 5779 cover the entire study area. Frames #70, 71 and 98 from the same mission, but at the larger scale (1:59,000), were used to compare the manual interpretation and delineation of the sites on the 1:118,000 imagery. Mission 114, CIR (1:120,000), flown on September 19, 1970 from 15.00-16.00 local time, was used to study the potential increase in surface mining acreage of the sites existing in September 1969,

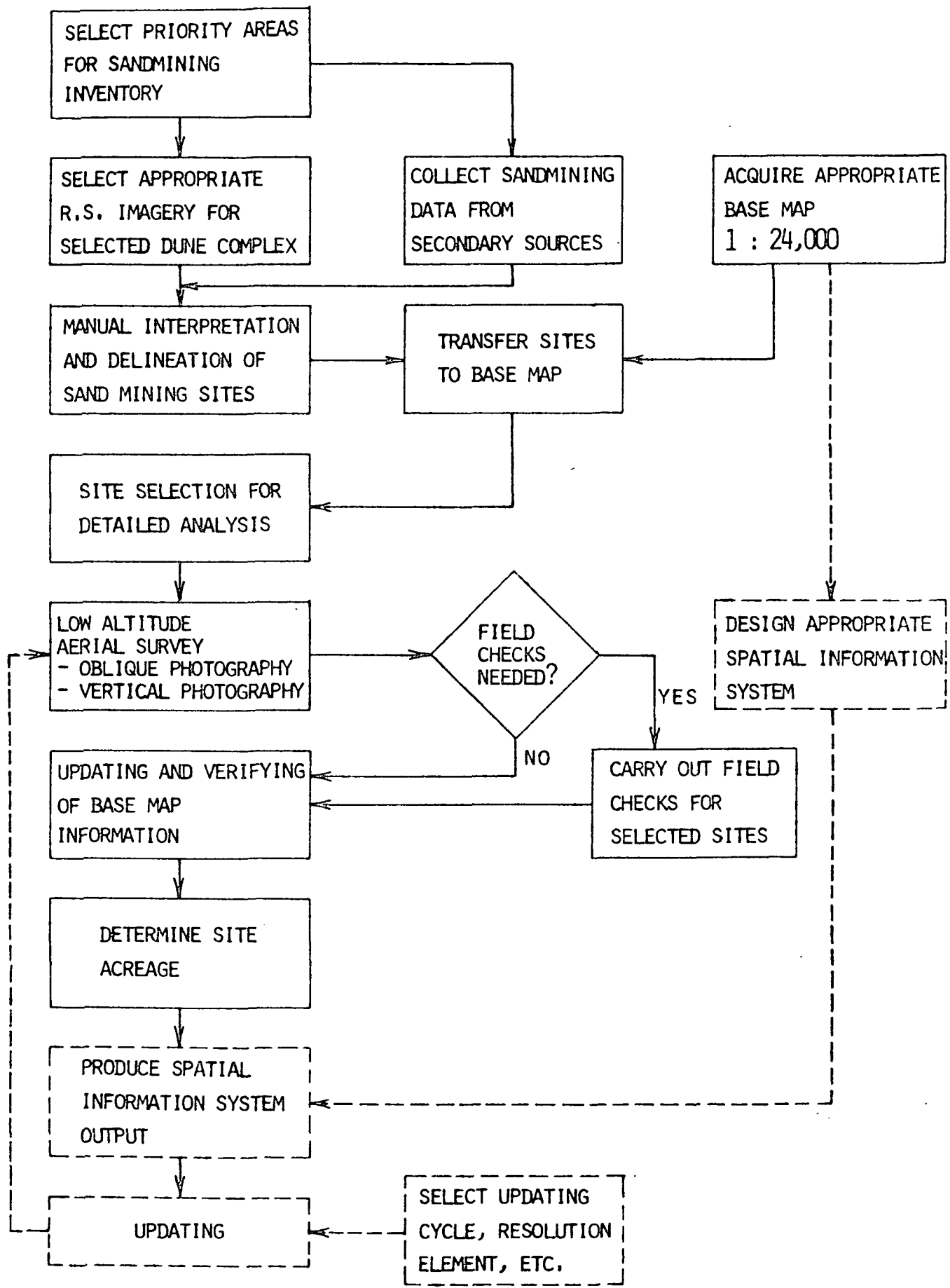


FIGURE 4.--FLOWCHART OF PROCEDURE USED (—) AND
PROCEDURE PROPOSED (---) FOR SANDMINING INVENTORY

or to discover the development of new sites developed during the 1969-70 period. No significant increase in sand mining acreage was detected and no new sites appeared to have been mined during this period.

After delineation of the sites on the CIR transparencies and transfer to 1:24,000 base maps, a low altitude aerial survey was carried out for the entire test area. Photo coverage was acquired for all of the 46 potential sand mining sites. With the use of a Bausch and Lomb 240 zoom stereoscope and a maximum magnification factor of 34, it was possible to verify the manual interpretation of the CIR high altitude imagery. This proved especially useful for the smaller sites of 1 to 5 acres, that showed up as significant high reflectivity areas on the 1:118,000 scale photography, but for which, because of a lack of specific interpretation features, a positive identification was hard to make.

The 35 mm. coverage allowed not only for a positive differentiation between small natural blow out areas and very small borrow pit/mining sites, but made it also possible to differentiate between the active and non-active status of the site, since sharply defined edges of man-made origin were clearly visible on the images, especially if photographed with an appropriate sun-angle. For about 15% of the mostly smaller sites, field checks were carried out. In most cases these sites proved to be of transitory nature (construction) and were then classified as such.

After the final updating and verifying process, areal measurements were carried out using a standard dot grid over the corrected sites on the base map.

Table 2 lists all the identified sites, their surface area, the final classification and the status of the mining site.

Table 2.--List of Identified Potential Mining Areas by Means of Manual Interpretation of CIR Image, September 1969. Final Verification Based on Aerial and Ground Survey, June 1977.

Site #	Approximate Surface Area (Acres)	Land Cover/Use	Sandmining	
			Active	Inactive
1	.40	Construction		
2	.25	Construction		
3	.69	Solid Waste Dump		X
4	.25	Construction		
5	1.05	Blow Out, Borrow Pit	X	
6	1.73	Blow Out, Borrow Pit		X
7	.70	Blow Out		
8	.84	Blow Out		
9	1.15	Blow Out, Borrow Pit	X	
10	.65	Construction		
11	1.38	Construction		
12	.78	Blow Out, Borrow Pit	X	
13	2.30	Blow Out		
14	8.51	Blow Out		
15	.65	Construction		
16	1.59	Construction		
17	.35	Blow Out		
18	.58	Forest Clearing, Blow Out		
19	1.61	Blow Out		
20	2.83	Borrow Pit, Blow Out	X	
21	.78	Blow Out		
22	1.40	Old Mining Site		X
23	217.58	Old Mine Complex		X
24	151.34	Residential		X
25	1.29	Old Mining Site		X
26	140.24	Mining Operation	X	
27	2.50	Blow Out		
28	1.38	Old Mining Site		X
29	15.87	Mining Operation	X	
30	80.50	Mining Operation	X	
31	2.88	Sand Pit		X
32	179.86	Old Mining Complex		X
33	4.26	Blow Out		
34	.75	Slope Erosion, Borrow Pit	X	
35	2.19	Blow Out		
36	2.99	Blow Out		
37	49.45	Mining Operation	X	
38	6.21	Construction		
39	10.81	Mining Site	X	
40	5.52	Blow Out		
41	.17	Blow Out, Borrow Pit		X
42	.58	Blow Out		
43	2.19	Mining Site		X
44	1.50	Industrial, Old Site		
45	40.94	Mining Site		X
46	1.96	Industrial, Stock Pile		

Comparison of Inventory Procedures

The inventory procedure as carried out by the Geological Survey of the DNR combines topographic relief information (primary dune complexes) with soil information and ownership data of the major sand mining companies in the area. Utilizing this procedure, the future potential for sand mining, based on soil suitability and ownership parameters can be assessed. The current status of the large active sites in terms of total acreage being mined has not been determined. With the information available to the DNR, the three (major) sand mining operations have been identified for the Muskegon test area. The estimated inventory cost involved amounts to approximately \$250 for the complete area, including the preparation of color coded overlays on the 1:24,000 base maps, field checks, etc.

The Remote Sensing Project inventory identified a total of 10 active and 12 inactive mining sites in the test area. These sites include the smaller borrow pit areas which might or might not be in commercial use. However, as far as legal implications are concerned, they represent, in many cases, illegal sand mining activities.

The RSP inventory is accurate, complete and current (July 1977) as far as land use/mining information classification is concerned. The surface area calculations are, however, based on the delineation of high reflectivity areas on the 1969 NASA imagery. Updated and highly accurate acreage calculations could be acquired using low altitude 70 mm. coverage for selected sites.

The current status of the sand mining sites reflects the photointerpretation based on surface texture of high reflectivity areas, shape, tonal

variation and other clues of the particular site under investigation. In some cases where a borrow pit operation is concerned, the extent of the mining impact is so minimal that actual field checks might be required. In the RSP inventory, field checks were carried out in all cases where any reasonable doubt existed about a definite classification.

The inventory cost per square mile was estimated at \$10.30. This amounts to \$31.84 per site identified and surveyed in the Muskegon test area.

Conclusions

A number of conclusions can be drawn from the case study. Probably most important is that by utilizing remote sensing techniques, it is possible to accurately inventory a relatively large area (68 square miles) within a limited time period and at a relatively low cost. The information gathered is up to date, allowing for immediate legal action in case of discovered violations. It provides, utilizing a time comparative analysis approach, the potential to assess past and future trends in sand mining, broken down by planning area if so desired. This type of analysis and the derived information would permit local and state decision makers to quantify the environmental impact of surface mining, and to use the information as a basis for the review of future permit applications. Furthermore, it is relatively easy to update the current status and the areal extent of the operation on a continuous basis, after initial identification of the mining sites.

Recommendations

A) Based on the inventory carried out in this case study, a procedure is proposed for future sand mining inventory work (see Fig. 4). This procedure allows for a systematic updating of the information gathered, based on a selected updating cycle and a resolution level (information unit). The cycle could vary from 1 to 4 times a year and the resolution level desired to monitor in detail mining impact over time could be 2.5 to 10 acres (1 to 4 ha. based on a UTM information grid).

In order to facilitate the updating procedure, a geographic information system should be designed which will allow for the systematic storage, retrieval and analysis of data in combination with appropriate location identifiers.

B) Research should be carried out to evaluate the best scale and type of aerial photography suitable to provide the desired level of detail of information needed for inventory and updating procedures. In efforts to monitor in detail the areal impact of the mining operation, the utilization of ground panels for survey purposes should be studied.

Within this basic research framework, a continuous evaluation should be carried out of the overall remote sensing potential (platform levels, systems, etc.) in order to determine the best method for data extraction, while taking into consideration time, cost and accuracy parameters.

Outcome

As a result of this demonstration application conducted under the NASA grant, the Michigan Department of Natural Resources has contracted

with the Remote Sensing Project for the development of procedures to monitor sand mining activities in Michigan and to prepare an inventory of sand mining sites along the Lake Michigan Shoreline (see Contract Activity, C2 reported elsewhere in this report).

A4. Preservation of the Grand Mere Dune Environment

Grand Mere Association
P.O. Box 140
Stevensville, Michigan 49127

The Grand Mere Area represents one of Michigan's most unique dune environments. Its uniqueness is based on the great diversity of ecosystems represented in the area; dunes (stable and unstable), open beaches, wooded uplands, wetlands, and lakes. The Grand Mere Association, a group of citizens concerned with the preservation of this unique complex, has maintained for the past three years a close working relationship with the NASA/MSU Remote Sensing Project. They have expressed concerns in terms of information requirements allowing for improved management decisions of the lands owned by the Association and the assessment of new land acquisition priorities.

Low altitude 70 mm. color aerial coverage was acquired in November 1977 to update the environmental information of the Grand Mere Complex. Copies of the photography were supplied to a conservationist employed by the Grand Mere Association, to be used for the mapping of the vegetation cover.

Analysis of the recession rates of vegetation as a result of intensive off-road-vehicle (ORV) use has provided data which the Grand Mere Association used to convince local property owners and township authorities of the need to prohibit ORV use in the area. Additional funding was provided to enforce this action by use of intensified police patrols resulting in approximately 200 traffic citations in the spring of 1977.

Analysis of the November 1977 imagery has shown that this policy has resulted in a significant regrowth of vegetation. The two sample areas selected show an increase in vegetation cover. For sample area #1 an increase of 2.635% and for sample area #2 an increase of 2.179%. This means a relative increase in vegetation regrowth of 8.52% for sample area #1, and of 4.44% for sample area #2. The vegetation recession trend has been reversed due to cooperation between authorities and a concerned citizen group, based on information provided by the NASA/MSU Remote Sensing Project.

It is essential to monitor the status of the Grand Mere environment as a response to management practices, recreation use intensities, erosion dynamics, etc. in the future. A close working relationship between the Grand Mere Association and the Remote Sensing Project as established has provided an excellent case study environment for environmental management efforts and exemplifies the unique value of remote sensing techniques for areas with similar characteristics as wildlife areas, state parks, etc.

B. USER SERVICES

Conducting demonstration applications understandably generate demands for further information by users. As agency knowledge and expertise in remote sensing materials and methods develop, the need for review, instruction and updating becomes unavoidable. Project personnel routinely provide consultation on relevant aspects of imagery usage, issue illustrative materials and offer guidance to foster further application engagements by current and prospective users.

In these ways the MSU Project staff serves as a reference service for an increasing number of public and private organizations. This kind of a service function involves providing NASA-generated imagery, training in the use of equipment, giving other general technical assistance, and directing inquirers to appropriate sources of further materials and information (books, articles, conference proceedings, manufacturers' catalogs, symposia, workshops, etc.).

More specifically, user services, among a larger checklist, commonly include such assistance activities as 1) problem identification; 2) data source identification; 3) data classification procedures; 4) identification of decisions that need to be made (policy and action choices); 5) determining data efficiencies to get at the policy and action choices; 6) assistance in identifying available imagery; 7) assistance in acquiring available imagery and equipment; 8) providing estimates of cost for conducting particular studies; 9) imagery interpretation training; 10) merging remotely-sensed data with other natural and cultural resource information (e.g. ground truth).

Any combination of such assistance activities produces varying scopes and intensities of primary instruction for selected agency personnel, thereby making them aware of the capabilities of remote sensing for day-to-day and long term needs.

Other than the on-going myriad routine activities of serving users during this reporting period, only two major user services occurred which deserve special mention. The first one is atypical of the customary range of user services, and involves endeavors within the University community by the Project leaders to petition for and receive official standing as a research and service unit. This would provide a basic nucleus of continuing annual budget whereby Project continuity can be achieved and the scope of undertakings can be substantively broadened. Such activities have limited "service" connotations except as related to the continuing effectiveness of the Remote Sensing Project.

The second citation describes a newly developing dimension which has the potential of becoming a major service function to an untapped, enormous potential clientele throughout Michigan reached via the extensive network of the Michigan Cooperative Extension Service. This involvement can make this activity of service a dominant function.

B1. Institutionalization of the Remote Sensing Project

The Michigan State University Remote Sensing Project has been in operation since 1971. Over the intervening years it has been a highly effective multi-disciplinary group of faculty, research specialists, and graduate research assistants from the academic disciplines of botany and plant pathology, computer science (engineering), crop and soil sciences, forestry, geography, geology, resource development, urban planning and landscape architecture. These areas are represented by eight University departments and schools, four colleges, plus the Agricultural Experiment Station and the Cooperative Extension Service. As of the end of this reporting period, nine faculty members participate actively, with four full-time research specialists and a varying number (10-15) of graduate and undergraduate research assistants (see Acknowledgements, page 2).

The cohesiveness and productivity of this unit continues to be most encouraging and intellectually profitable; but it has been operating without any official recognition by the University administrative hierarchy. The success of this Project continues to be engendered by three main forces: 1) by a strong mutual interest and motivation in the utility of remote sensing technology as an important instrument for societal needs; 2) by a remarkable collegiality; and 3) by the continuing generous financial support from the Office of University Affairs of NASA.

As broad recognition for the work produced by the Project has grown throughout Michigan, so have opportunities to serve a larger clientele, to engage in a greater variety of research and service activities beyond

the scope of work agreed upon for coverage by the NASA Grant, and to build toward a more assured continuity. Project leaders judged that the collective operations in remote sensing should be officially recognized by the University by endowing it with the status of a "center" or "institute" and providing an annual budget for a small permanent administrative staff with a given basic scope of continuing operation. . .to institutionalize the ongoing research and service functions being carried forward by the MSU Project in Remote Sensing.

During this reporting period, major steps were initiated in seeking this objective. Four major component goals are now being programmed as an overall organizational strategy:

1. Familiarize Key Administrators. The Project has been in operation for seven years and has significant achievements which have not always been made fully evident to key administrators within the University. As a first priority, meetings were conducted to familiarize such officials (chairmen of participating departments and schools, college deans and directors, and central University administrators) with the demonstration applications, the range of user services, and the increasing contract activities of the Remote Sensing Project.
2. Adopt Functional Objectives. In order to avoid any potential problems of overlapping objectives with other University units, a statement of functional objectives, both current and future, will be the focus of subsequent discussions with key administrators.

3. Reach Agreements. With objectives clarified, it is intended that agreements regarding the nature of the institutionalized practices . . .organizational structure and operational scope and substance . . .will be reached by the faculty investigators, research staff, department chairmen and college deans and directors.
4. Effect Funding. Agreement on the nature of an institutionalized Remote Sensing Project between these multiple parties will then allow the identification of funding mechanisms and sources, and the formulation of budgeting requests for the Project's future operations.

As of this reporting, Project familiarization sessions have been conducted with the Directors of the Agricultural Experiment Station (AES), the Cooperative Extension Service (CES), and the Deans of the Colleges of Social Science, Natural Science, and Engineering. These presentations were well received and the administrators expressed general support for the institutionalization concept. They encouraged formulation of a specific proposal. The Directors of AES and CES want to participate in expanding the scope of certain Project applications and services to a wider audience in the State (see section B2 of this report, which describes proposed initial activities under Cooperation Extension Service support).

Project investigators are now clarifying the objectives of a proposed "center" (component #2), and will subsequently work on components of "Agreements" (#3), and the elements of budget support (#4). Completion of the proposal and achievement of the official center is planned this year.

B2. Working Association with the Cooperative Extension Service

Arrangements were initiated to work with the Michigan State University Cooperative Extension Service (CES) to provide remote sensing materials, assistance in program development, and in-service training to the county extension directors, as well as to appropriate program specialists and other staff. It is expected that through this network of key CES personnel, many individuals, private enterprises, and local planning and management agencies will be informed of the MSU remote sensing services.

As an initial step in this new association, a questionnaire was developed by which CES personnel interest in these various remote sensing services could be surveyed and evaluated. The questionnaire was scheduled for distribution early in January 1977 to the substantial roster of county extension directors as part of a package of informational materials, including the newly published Guide to Aerial Imagery of Michigan.* As reported in the preceding Progress Report (December 1976-May 1977), preparation of the Guide to Aerial Imagery of Michigan had been a continuing effort for over two years. It was built upon an earlier, more limited "Guide" and resulted in a document of considerable magnitude providing information on the full range of available remotely sensed imagery of Michigan. The Director of the Cooperative Extension Service pledged some financial support to compile responses to the questionnaire as well as assistance for other services, such as reproducing and distributing Remote Sensing Project publications, including appropriate follow-up activities*.

In these negotiations it was agreed that longer term efforts, with CES support, will focus on several other program objectives, namely: 1) the compilation of an index of basic natural resource information for the State, an

* So accomplished as of February 1978.

effort which will update and expand upon the Mapping and Photography Directory prepared by the Michigan Department of Natural Resources; 2) the development of educational programs on "Natural Resources Inventory and Land Use" in cooperation with the Division of Land Programs in the Michigan Department of Natural Resources; and 3) the establishment of in-service remote sensing programs for extension directors and local groups within the State.

The CES is an integral part of the University with representatives living in the local communities and closely related to people and their problems. County extension staff (or "agents") are located in each of Michigan's 80 County Extension Service offices. Program specialists in more than 26 subject-matter fields support the field staff in programs which require special knowledge to solve local problems.

The overall objective of the CES is to provide educational programs to help individuals and groups to make sound decisions to earn and manage income, develop talents and capacities, foster optimum living environment for family and individual, and plan for wise use of natural resources and create better communities in which to live and work.

A working association with the CES can carry considerable significance for extending knowledge about remote sensing, reaching a substantial new clientele throughout Michigan, and possibly for opening up new opportunities for innovative demonstration applications. With support from the CES, other kinds of service-related activities could be handled more effectively, such as responding to inquiries about remote sensing, with the general result of allowing research staff to concentrate with less interruption on NASA Grant related studies. These kinds of benefits could reduce demands on the NASA Grant funds and strengthen the effectiveness of the grant-supported research.

C. CONTRACTUAL SERVICES

Just as the steady flow of Project demonstration applications has generated an increasing amount of user services, it has also created a contractual demand for information derived from remotely-sensed data. Most agencies now have a rudimentary understanding of remote sensing techniques, however, they cannot afford to employ and retain staff with photo-interpretation and cartographic skills to meet periodic needs. Neither do they have the necessary equipment to derive the essential information from remotely-sensed data.

With more and more LANDSAT imagery becoming commonly available and used, considerable expertise is needed for both "manual" (visual) and digital interpretation. Very few private and public organizations have capabilities of deriving information from this source and they must therefore depend on contracted services.

LANDSAT 3's improved image resolution and quality will certainly increase this dependency on special contractors.

The MSU Project has been called upon repeatedly to provide such services when an application does not meet the established criteria for a NASA funded demonstration cited in Section A, Demonstration Applications (see page 9). They have been performed for a variety of private organizations and federal, state, regional, and local government agencies. All expenditures are cost reimbursable unless some part of the service involves a demonstration application. In this situation, the agency pays for all costs other than the innovative application research. All of the following contractual activities are on a cost reimbursable basis.

C1. Comprehensive Resource Inventory and Evaluation System (CRIES)

U.S. Department of Agriculture
Economics, Statistics, and Cooperatives Service
Room 305, Manly Miles Building
1405 South Harrison Road
East Lansing, Michigan 48823

The CRIES project continued throughout this reporting period. CRIES is a cooperative program between Michigan State University and the Economic Research Service of the U.S. Department of Agriculture and is funded by the Agency for International Development. The objective of the project is to create the technical skills and institutional capabilities of developing countries to conduct agricultural planning and other resource management studies. The project is a multi-agency and multi-disciplinary effort. The Remote Sensing Project at MSU is contributing technical skills and services in two major project areas: remote sensing and geographic information system development.

During this reporting period, the LANDSAT test in the Dominican Republic was completed and a report issued (reference #62 in Appendix). The test comprised four test areas within the Dominican Republic, two of which were interpreted visually using LANDSAT imagery and digitally using the LANDSAT data tapes. A comparison of results, costs, and benefits of applications for the two approaches is currently underway. As an extension of the remote sensing activity, preliminary plans were drawn up and approved to conduct a land use/cover inventory of Cost Rica using visual interpretation of LANDSAT imagery. This activity will be a more involved one than in the Dominican Republic, with the data derived from LANDSAT

contributing to a major extent in the subsequent economic analysis models of the CRIES project.

The Resource Analysis Program (RAP), which has been under development by the Remote Sensing Project for several years, was selected to comprise the analytical program component of a national mapping system being installed in the Dominican Republic as part of the CRIES project. Plans for customizing the computer program to the needs of the Dominicans were developed. By the end of the reporting period, the program was being converted from a CDC computer to an IBM 370/115, the host computer in the Dominican Republic. The compilation of the Dominican map data files was completed during this time period. The files contain data on km² grid cells for an area of 300 km. by 400 km. There are nine maps currently stored in these map files, resulting in nearly 1.1 million data elements in the map files. Preliminary activity also began regarding geographic information systems in the other CRIES cooperating countries, Costa Rica and Nicaragua.

C2. Inventory of Sand Mining Sites in Michigan's High-Priority Sand Dune Areas

Geology Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

The objectives of this contract are: 1) determine the optimal remote sensing techniques and information system structure to periodically monitor sand mining activities; 2) acquire aerial photography of sand mining operations in the high-priority sand dune areas of Michigan; 3) prepare an inventory of sand mining activities in the high-priority sand dune areas of Michigan utilizing the information generated in objective one; and 4) develop a sand mining surveillance procedure manual.

The proposed research and inventory efforts are aimed at satisfying the sand mining monitoring requirement of the "Sand Dune Protection and Management Act," (Act No. 222, State of Michigan, July 30, 1976) a direct spin-off from a recent case study in the Muskegon area carried out under the NASA grant (see Application Activity A3, page 21 in this report).

The main research objective is to develop efficient cost effective data extraction and analysis procedures for providing accurate and up-to-date information on sand mining activities. This information should be suitable for the legal enforcement of the sand mining legislation and should provide basic information for the evaluation of permit applications for future sand mining operations.

This effort will focus on the development of appropriate inventory procedures utilizing remote sensing techniques, associated data extraction,

storage, retrieval, and updating procedures within the framework of a geographical information system. A secondary research objective will be the development and evaluation of tools to monitor and survey sand mining activities over time. Ground and aerial survey techniques will be studied to pinpoint the areal extent of mining sites utilizing specific survey panels of selected size, shape, color, construction, etc.

Using the research findings, an inventory will be carried out for seven high-priority sand dune areas along the Lake Michigan Shoreline (a total area of approximately 188 square miles).

The inventory procedure for the high-priority areas will include the acquisition of 35 mm. color oblique photography of all identified sites, and more detailed, larger scale 70 mm. vertical color infrared or color photography of selected sand mining operations where area and volume measurements are required.

The result of this research will be prepared in the form of recommendations for inventory and monitoring procedures. The results of the detailed inventory will be presented according to the selected information system format including the compiled photo base of 35 and 70 mm. photography.

C3. Inventory of Sand Dune Types in Michigan's High-Priority Sand Dune Areas

Geology Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48909

The Sand Dune Protection and Management Act (State of Michigan, Act 222, 1976) calls for an inventory of the barrier dunes along the Great Lakes Shoreline in the State. This contract is aimed at developing an inventory through the analysis of aerial imagery available from several sources in the State including the MSU Remote Sensing Project, and the Michigan Department of State Highways and Transportation.

Preliminary work by Project personnel under the NASA Grant has established the feasibility of using aerial imagery for delimitation of dune complexes in the Grand Mere Area of Michigan (reported in the previous Semi-Annual Progress Report, December 1976-May 1977 and reference #60 in the Appendix of this report).

Scientific documentation on Michigan's dune lands is, however, incomplete with respect to typology dynamics and human use so that preliminary definitional work will be necessary before the inventory is attempted. With adequate definitions, remote sensing techniques can provide the inventory information necessary to evaluate barrier dunes and "their effect on aesthetic, environmental, economic and agricultural interests in this state" (Act 222, Section 3d).

The objectives of this contract are: 1) to develop a classification system by which the various dune types of the state can be defined on the

basis of their morphologic (quantitative and qualitative) characteristics, and 2) use appropriate remote sensing techniques to inventory all dune types and land uses within selected high-priority areas along Lake Michigan. The inventory will specifically allow identification and designation of barrier dunes as required by the Sand Dune Protection and Management Act (State of Michigan, Act 222, July 30, 1976).

The objectives, criteria, techniques, imagery and expected products are listed in Table 3.

Table 3.--Dune Inventory and Classification.

OBJECTIVE	ASPECT	TECHNIQUE	IMAGERY	EXPECTED PRODUCTS
A. <u>Dune Typology</u>	Location Height Width Average Slope Volume Area Continuity Age	Stereoscopic and Photogrammetric Analysis Transferring Plotting Morphography and Morphometry	Large Scale B&W and CIR	Color-Overlays of Type Areas Cross Sections Map of Dune Physiography (1:63,360)
B. <u>Dune Cover/Use Type</u>	Vegetation As- sociations Percentage of Cover (bare, grass, shrub, forest)	Densitometry and Planimetry (with Scanning Densi- tometer Data color 704) Visual Analysis	Large and Medium Scale CIR SKYLAB and LAND- SAT Frames	Color Display of Cover Types Map of Exposed Sand Terrain
C. <u>Land Use Type</u>	Prevailing Land Use (degree of anthropogenic interference with natural system)	Categorization through Michigan Land Use/Cover Classification System	Large and Medium Scale B&W and CIR	Map of Land Use

C4. Shiawassee National Wildlife Refuge Vegetation Inventory

Johnson & Anderson, Inc.
P.O. Box 1166
2300 Dixie Highway
Pontiac, Michigan 48056

U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

Johnson & Anderson, Inc. (consulting engineers), under contract from the U.S. Fish and Wildlife Service, subcontracted with the MSU Remote Sensing Project for the provision of a vegetation inventory of the Shiawassee National Wildlife Refuge.

The wildlife refuge is an area 15 sq. mi. (39 sq. km.) in size located in Saginaw County approximately 5 miles south of the City of Saginaw. Situated in an area of prime agricultural land at the confluence of four major rivers (the Cass, Flint, Shiawassee, and Titabawassee), the wildlife refuge is located entirely within the 100 year floodplain.

The inventory entails identifying 12 vegetation cover types (mainly lowland hardwoods, wetlands, and cropland) to a minimum 5-acre type size from 1:60,000 NASA high altitude color infrared imagery taken on May 13, 1975.

A 1:24,000 mylar vegetation map and area calculations of each vegetative category will be provided for use in preparing a master plan and subsequent environmental assessments for refuge development projects.

A p p e n d i x

P U B L I C A T I O N S a n d P R E S E N T A T I O N S

. of the Michigan State University Project

-
1. "Investigation of Land Resource Use in Southeast Michigan." J. G. Ahl, M. G. Boylan, D. L. Mokma, W. L. Myers, S. W. Schar and R. D. Vlasin. Proceedings of the Eighth International Symposium on Remote Sensing of Environment. pp. 23-33. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1972.
 2. Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment. Environmental Research Institute of Michigan. Ann Arbor, Michigan. December 1972. 107 p.
 3. Users Guide to High Altitude Imagery of Michigan. Mark C. Sullivan and Stephen W. Schar. Michigan State University. East Lansing, Michigan. April 1973. 39 p.
 4. Proposed Land Use Classification System. Project for the Use of Remote Sensing in Land Use Policy Formulation. Michigan State University. East Lansing, Michigan. July 1973. 26 p.
 5. Proceedings of the Conference on Practical Applications of Remote Sensing. (May 15-16). Ken Keifenheim and Stephen W. Schar, Editors. Michigan State University. East Lansing, Michigan. September 1973. 72 p.
 6. Image Interpretation for a Multi-Level Land Use Classification System. Mark C. Sullivan and Gary Higgs. Michigan State University. East Lansing, Michigan. September 1973. 35 p.
 7. The Use of Color Infrared Photography for Wetlands Mapping: With Special Reference to Shoreline and Waterfowl Habitat Assessment. William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 33 p.
 8. Upper Kalamazoo Watershed Land Cover Inventory. Benjamin Richason III and William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 39 p.
 9. "A Comparative Analysis of Remote Sensing Scale/System Attributes for a Multi-Level Land Use Classification System." Mark C. Sullivan and Gary Higgs. Proceedings of the American Society of Photogrammetry Fall Convention. pp. 335-367. American Society of Photogrammetry. Falls Church, Virginia. October 1973.

10. Evaluating Data Collection Costs with Emphasis on Remote Sensing. Marilyn J. Bennett. M.S. Thesis, (unpublished). Michigan State University. East Lansing, Michigan. 1974. 146 p.
11. "Focus on Community Development." Michigan Science in Action. Report No. 26. Michigan State University Agricultural Experiment Station. East Lansing, Michigan. February 1974.
12. "Resource Inventory for Multi-Agency Watershed Planning." W. R. Enslin, B. Richason III and M. J. Bennett. Remote Sensing of Earth Resources. Volume III. pp. 653-670. The University of Tennessee Space Institute. Tullahoma, Tennessee. March 1974.
13. "The Use of Color Infrared Photography for Wetland Assessment." William R. Enslin and Mark C. Sullivan. Remote Sensing of Earth Resources. Volume III. pp. 697-720. The University of Tennessee Space Institute. Tullahoma, Tennessee. March 1974.
14. "Operational Remote Sensing for Land Capability Analysis of Michigan." Myles G. Boylan and Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974. Not Available.
15. "A Quick Procedure for Developing Environmental Planning Inventories in Michigan." Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan, March 1974.
16. "Color-Infrared Airphotos as a Source of Forest Resource Data for Regional Information Systems: Putting Remote Sensing Technology to Work in Northwestern Michigan." William D. Hudson and Wayne Myers. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.
17. "Collection and Manipulation of Land Use Information for Corridor Analysis." Mark C. Sullivan. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.
18. Remote Sensing in Michigan for Land Resource Management: Waterfowl Habitat. A. N. Sellman, I. J. Sattinger, L. B. Istvan, W. R. Enslin, W. L. Myers, M. C. Sullivan. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April, 1974. 43 p.
19. "Resource Analysis Applications in Michigan." S. W. Schar, W. R. Enslin, I. J. Sattinger, J. G. Robinson, R. S. Fellows, K. R. Hosford and J. G. Raad. Summaries of the Ninth International Symposium on Remote Sensing of Environment. pp. 236-237. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.

20. "Design Concepts for Land Use and Natural Resources Inventories and Information Systems." R. L. Shelton and E. E. Hardy. Summaries of the Ninth International Symposium on Remote Sensing of Environment. pp. 53-54. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.
21. "Resource Analysis Applications in Michigan." S. W. Schar, W. R. Enslin, I. J. Sattinger, J. G. Robinson, R. S. Fellows, K. R. Hosford, and J. G. Raad. Proceedings of the Ninth International Symposium on Remote Sensing of Environment, Vol. III, pp. 2073-2081. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.
22. "Design Concepts for Land Use and Natural Resources Inventories and Information Systems." Ronald L. Shelton and Ernest E. Hardy. Proceedings of the Ninth International Symposium on Remote Sensing of Environment. Vol. I. pp. 517-536. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.
23. Determining Regional Soil Losses Resulting from Construction Activities. S. E. Tilmann, D. L. Mokma and R. L. Stockman. Project for the Use of Remote Sensing in Land Use Policy Formulation. Michigan State University. East Lansing, Michigan. January 1975. 21 p.
24. "Improved Resource Use Decisions and Actions through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Abstracts of the NASA Earth Resources Survey Symposium. pp. 231-233. Johnson Space Center. Houston, Texas. June 1975.
25. Michigan Land Cover/Use Classification System. Michigan Land Use Classification and Referencing Committee. Office of Land Use, Department of Natural Resources. Lansing, Michigan. July 1975. 60 p.
26. "Improved Resource Use Decisions and Actions Through Remote Sensing." R. Hill-Rowley, M. Boylan, W. Enslin and R. Vlasin. Proceedings of the NASA Earth Resources Survey Symposium. Vol. IC. pp. 1747-1767. Johnson Space Center. Houston, Texas. September 1975.
27. "Improved Resource Use Decisions and Actions Through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Summaries of the Tenth International Symposium on Remote Sensing of Environment. pp. 112-113. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1975.
28. "Survey of Recent Resource Applications in Michigan." W. C. Taylor, W. R. Enslin, C. E. Olson, Jr., and I. J. Sattinger. Summaries of the Tenth International Symposium on Remote Sensing of Environment. pp. 123-125. Ann Arbor, Michigan. October 1975.
29. "Improved Resource Use Decisions and Actions through Application of High Altitude Color-Infrared Imagery." W. R. Enslin, M. Boylan, R. Hill-Rowley and R. D. Vlasin. Proceedings of Applications of Remotely-Sensed Data in North Central United States. p. 35. American Institute of Aeronautics and Astronautics and Bendix Aerospace Systems Division, Ann Arbor, Michigan. November 1975. (Abstract).

30. "Improved Resource Use Decisions and Actions Through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Proceedings of the Tenth International Symposium on Remote Sensing of Environment. pp. 793-801. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1975.
31. "Survey of Recent Resource Applications in Michigan." W. C. Taylor, W. R. Enslin, C. E. Olson Jr., and I. J. Sattinger. Proceedings of the Tenth International Symposium on Remote Sensing of Environment. pp. 857-865. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1975.
32. "Remote Sensing of Abandoned Vehicles for County Planning." Salleh M. Nor. Remote Sensing of Earth Resources, Vol. V, edited by F. Shahrokhi, The University of Tennessee Space Institute, Tullahoma, Tennessee, 1976. (In Press).
33. "Improved Land Use Decisions and Actions in Michigan Through Remote Sensing." Richard Hill-Rowley and William R. Enslin. Proceedings of the Association of American Geographers, Vol. 8. pp. 132-136. Association of American Geographers, Washington, D. C. April 1976.
34. "Remote Sensing for Identifying Essential Lands." William R. Enslin. Conference Proceedings: Protection of Essential Lands. pp. 80-84. Department of Resource Development, Michigan State University, East Lansing, Michigan. April 1976.
35. Report on the Land Use/Cover Map and Soil Limitations Maps for the 1865 Treaty Lands of the Saginaw-Chippewa Indian Tribe. NASA Remote Sensing Project, Michigan State University. East Lansing, Michigan, April 1976. (Mimeographed).
36. "Soil Management Groups: A useful tool for interpretive and glacial maps." S. E. Tilmann and G. Larson. Presented at the North-Central meeting of the Geological Society of America, Kalamazoo, Michigan. April 1976. Not Available.
37. "Evaluating limitations to ground water recharge by a multi-dimensional scaling model." S. E. Tilmann. Presented at the North-Central meeting of the Geological Society of America, Kalamazoo, Michigan. April 1976. Not Available.
38. A Strategy for Land Use/Cover Data File and Map Preparation. Stephen E. Tilmann and Robert H. Rogers. Bendix Aerospace Systems Division. Ann Arbor, Michigan. May 1976. 21 p. (Mimeographed).
39. 1972 Land Cover/Use Inventory of Clinton, Eaton and Ingham Counties, Michigan. Remote Sensing Project, Michigan State University, East Lansing, Michigan. June 1976. 49 p. (Mimeographed).

40. Report on the Natural Resource Information System Developed for the Tri-County Regional Planning Commission. Remote Sensing Project, Michigan State University, East Lansing, Michigan. July 1976. 95 p. (Mimeographed).
41. Identifying and Mapping Forest Resources From Small-Scale Color Infrared Airphotos. W. D. Hudson, R. J. Amsterburg Jr., and W. L. Myers. Michigan Agricultural Experiment Station Research Report 304. Michigan State University, East Lansing, Michigan. July 1976. 12 p.
42. Documentation: 1970 SEMCOG Land Use Inventory. Johnson, Johnson and Roy, Inc. Ann Arbor, Michigan. July 1976. 22 p. (Mimeographed).
43. Engineering Properties of Soil Management Groups. S. E. Tilmann and D. L. Mokma. Michigan Agricultural Experiment Station Research Report 313. Michigan State University, East Lansing, Michigan. August 1976. 12 p.
44. Soil Management Groups and Soil Erosion Control. S. E. Tilmann and D. L. Mokma. Michigan Agricultural Experiment Station Research Report 310. Michigan State University, East Lansing, Michigan. August 1976. 16 p.
45. "Mapping of Remote Sensing Data for Michigan Agencies." Kenneth E. Keifenheim. Presented at the East Lakes Division Meetings, Association of American Geographers, Ann Arbor, Michigan. October 15, 1976.
46. "Keeping Our Resources Under Surveillance." Laurie De Firmian and Roberta Yafie. Supplement to the Michigan State University Alumni Magazine, Vol. 2, No. 4. pp. 4-5. College of Agriculture and Natural Resources, Michigan State University, East Lansing, Michigan, Nov./Dec. 1976.
47. "MSU Remote Sensing Project" in 89th Annual Report, Agricultural Research in the Bicentennial Year Research Report 319. pp. 13-15. Agricultural Experiment Station, Michigan State University, East Lansing, Michigan. December 1976.
48. "Michigan Resource Inventories: Characteristics and Costs of Selected Projects Using High Altitude Color Infrared Imagery." W. R. Enslin and R. Hill-Rowley. Proceedings of the First Conference on the Economics of Remote Sensing Information Systems. pp. 194-212. San Jose State University, San Jose, California. January 1977.
49. "A Computer Software System for Integration and Analysis of Grid-Based Remote Sensing Data with Other Natural Resource Data." S. E. Tilmann, W. R. Enslin and R. Hill-Rowley. Proceedings of the 43rd Annual Meeting of the American Society of Photogrammetry. pp. 3-14. American Society of Photogrammetry, Washington, D.C. February 1977.

50. "A Procedure for Merging Land Cover/Use Data from Landsat, Aerial Photography, and Map Sources: Compatibility, Accuracy and Cost." W. R. Enslin, S. E. Tilmann, R. Hill-Rowley, and R. H. Rogers. Proceedings of the 43rd Annual Meeting of the American Society of Photogrammetry. pp. 449-458. American Society of Photogrammetry, Washington, D.C. February 1977.
51. "Estimation of Old Field Ecosystem Biomass Using Low Altitude Imagery." Salleh Mohd. Nor, Gene Safir, T. M. Burton, J. E. Hook and G. Schultink. Summaries of the 11th International Symposium on Remote Sensing of Environment. p. 85. ERIM, Ann Arbor, Michigan. April 1977.
52. "Application of Aerial Photography to Water-Related Programs in Michigan." W. R. Enslin, R. Hill-Rowley and S. E. Tilmann. Summaries of the 11th International Symposium on Remote Sensing of Environment. pp. 100-101. ERIM, Ann Arbor, Michigan. April 1977.
53. "Estimation of Old Field Ecosystem Biomass Using Low Altitude Imagery." Salleh Mohd. Nor, Gene Safir, T. M. Burton, J. E. Hook and G. Schultink. Proceedings of the 11th International Symposium on Remote Sensing of Environment. pp. 711-718. ERIM, Ann Arbor, Michigan. April 1977.
54. "Application of Aerial Photography to Water-Related Programs in Michigan." W. R. Enslin, R. Hill-Rowley and S. E. Tilmann. Proceedings of the 11th International Symposium on Remote Sensing of Environment. pp. 807-816. ERIM, Ann Arbor, Michigan. April 1977.
55. "Characteristics of Remote Sensing Applications in Michigan." Richard Hill-Rowley and William R. Enslin. Abstracts. Association of American Geographers. p. . Association of American Geographers, Washington, D.C. April 1977.
56. "Characteristics of Remote Sensing Applications in Michigan." Richard Hill-Rowley and William R. Enslin. Presented at the 73rd Annual Meeting of the Association of American Geographers. Salt Lake City, Utah. April 25, 1977. (Mimeographed).
57. "The Acquisition and Integration of Land Use Data for Regional Planning." Richard Hill-Rowley and William R. Enslin. Presented at the 3rd Symposium of the American Institute of Aeronautics and Astronautics on the Applications of Remotely Sensed Data. Ann Arbor, Michigan. May 1977.
- *58. "Photo Interpretative Procedures in Assessing River Recreation Potential." Salleh M. Nor and Richard Hill-Rowley. Proceedings of the 1977 Scenic Rivers Symposium. pp. 86-89. Louisiana State University, Baton Rouge, Louisiana. June 1977.

- *59. Land Cover Analysis of Region V Genesee, Lapeer and Shiawassee Counties.
L. E. Reed and W. R. Enslin. Bendix Report BSR 4284. July 1977.
- *60. "Impact Analysis of Off-Road-Vehicle Use on Vegetation in the Grand Mere Dune Environment." Ger Schultink. Proceedings of the Sixth Biennial Workshop on Color Aerial Photography in the Plant Sciences and Related Fields. pp. 132-140. American Society of Photogrammetry, Fort Collins, Colorado. August 9-11, 1977.
- *61. Visual Interpretation of LANDSAT Imagery for Land Cover and Land Use of Selected Test Sites in the Dominican Republic. Salleh Mohd. Nor, Sandra Habowski and Stephen E. Tilmann. Remote Sensing Project, Michigan State University, East Lansing, Michigan. August 1977.
- *62. Land Use Inventory Through Merging of LANDSAT (Satellite), Aerial Photography, and Map Sources. Robert H. Rogers, Larry E. Reed, William R. Enslin, Kenneth E. Keifenheim, Thomas H. Haga and Robert Karwoski. Bendix Report BSR 4292. September 2, 1977.
- *63. Resource Analysis Program: User's Guide to RAP. Stephen E. Tilmann. Remote Sensing Project, Michigan State University, East Lansing, Michigan. October 1977.
- *64. Guide to Aerial Imagery of Michigan. William R. Enslin and Richard Hill-Rowley. Michigan Agricultural Experiment Station Research Report 340. November 1977.

*Published or presented this reporting period.

